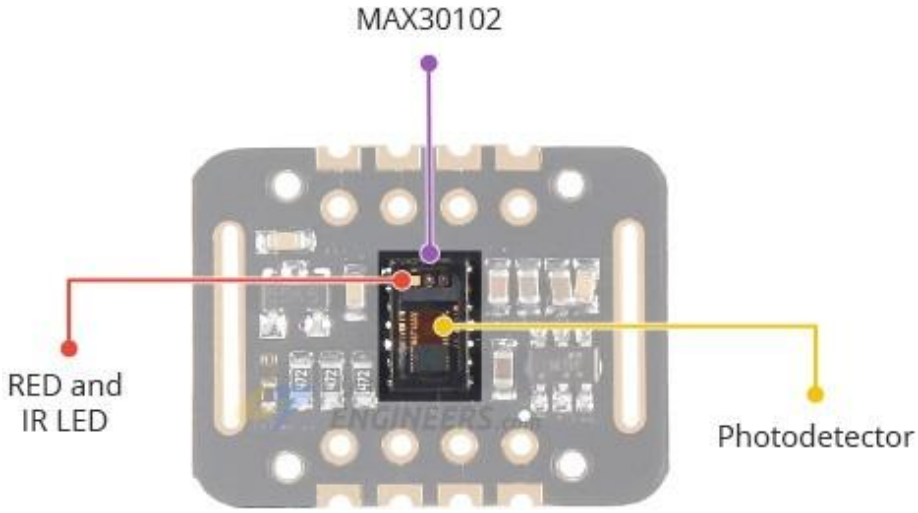
MAX30102 Sensor

The MAX30102 sensor is a module used for measuring heart rate and blood oxygen saturation. This module integrates a pulse oximeter and heart rate sensor IC, including two LEDs, a photodetector, optimized optics, and low-noise analog signal processing. It can detect signals for pulse oximetry (SpO2) and heart rate (HR), and it also has ambient light suppression capabilities.



Internal Structure & Working Principle of MAX30102

Hardware Structure:

The MAX30102 pulse oximeter and heart rate sensor contains two LEDs that emit red (RED) and infrared (IR) light. When these lights illuminate human tissue, some of the light is absorbed, and some is reflected and captured by the photodetector, which converts it into an electrical signal. This electrical signal contains both DC (direct current) and AC (alternating current) components, where the AC component's frequency corresponds to the pulse rate. The heart rate can be determined from any of these electrical signals.

Power Requirements:

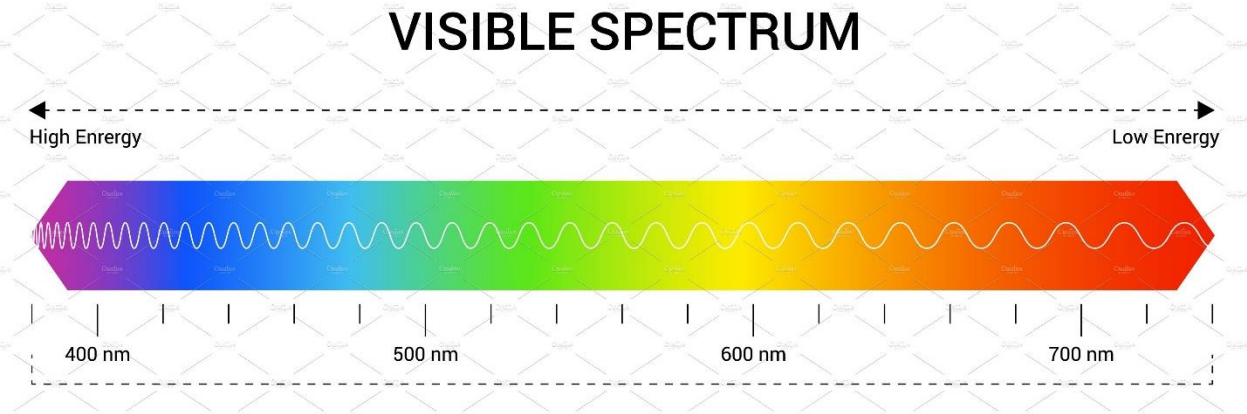
This sensor requires 1.8V for the IC and 3.3V for the LEDs, with an onboard voltage regulator. The solder jumper on the back of the PCB allows for selecting between 3.3V and 1.8V logic levels, with 3.3V being the default, making it compatible with Arduino. It can also operate at 1.8V logic levels. The MAX30102 features low power consumption, using less than 600µA during measurement and only 0.7µA in standby mode, making it suitable for battery-powered handheld devices, wearables, or smartwatches.

I2C Interface:

The module uses a simple two-wire I2C interface for communication with microcontrollers. It has fixed I2C addresses: 0xAE for write operations and 0xAF for read operations.

Optical Principle:

The MAX30102 contains two high-intensity LEDs (red at 660nm and infrared at 880nm) and a photodetector. These LEDs alternately emit light, and the sensor measures the light reflected from the skin to calculate blood oxygen saturation and heart rate.

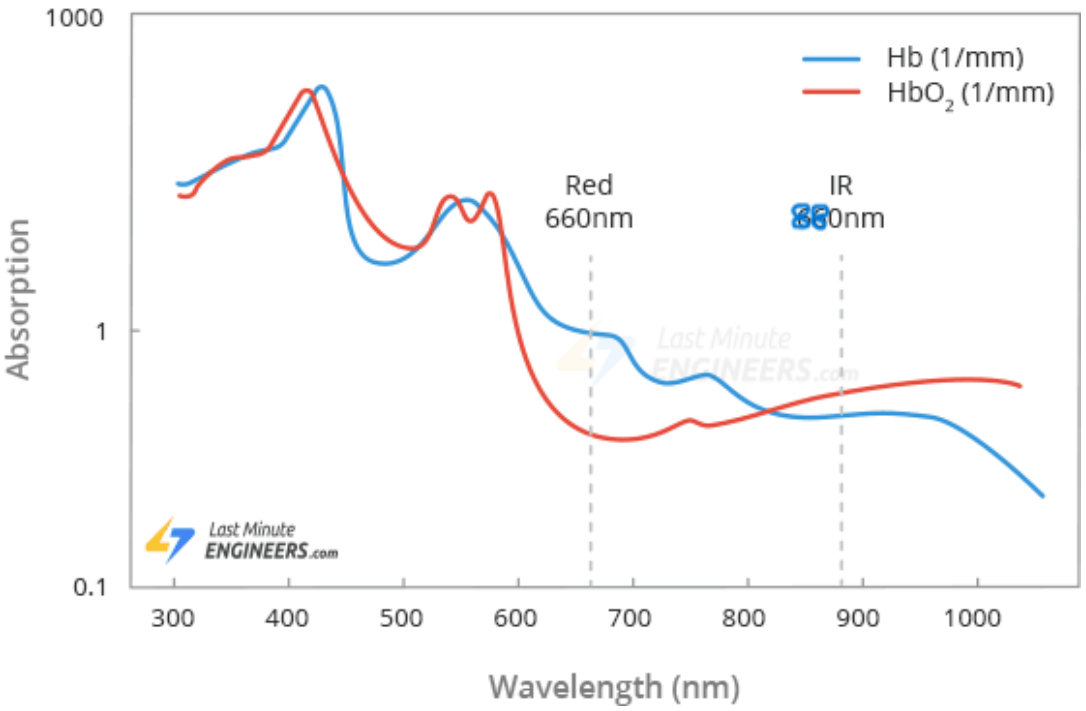


The MAX30102 works by shining red and infrared light onto a thin skin area, such as a finger or earlobe, and using the photodetector to measure the amount of reflected light. This method, known as Photoplethysmography (PPG), uses optical techniques to measure blood volume changes. When light is projected onto the skin, some is reflected to the sensor while some is absorbed by the blood. By detecting changes in the reflected light, the PPG can generate waveforms that synchronize with heartbeats, reflecting heart rate and blood circulation status.

Working Principles: The operation of the MAX30102 can be divided into two parts: Pulse Oximetry and Heart Rate Measurement.

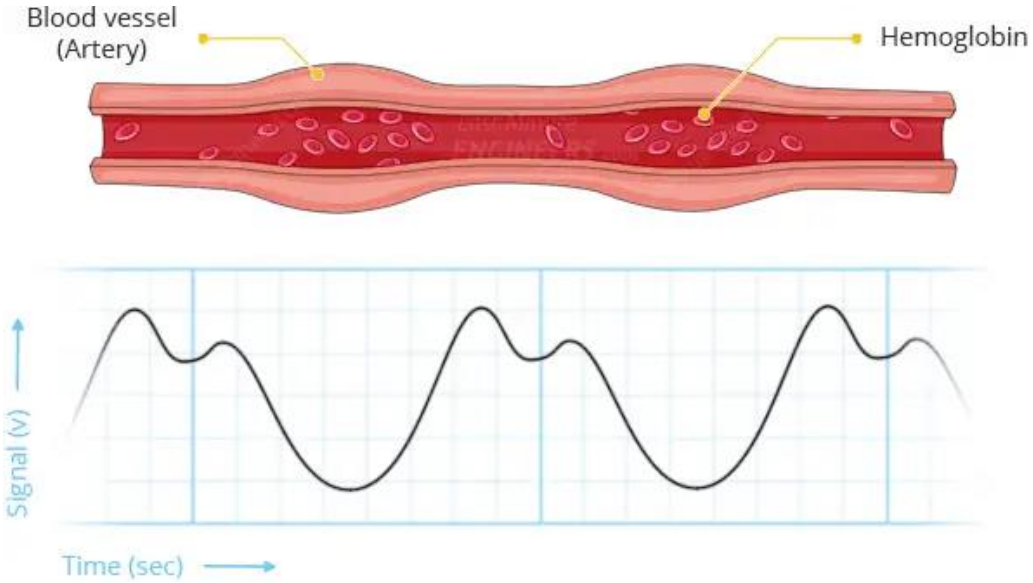
Pulse Oximetry:

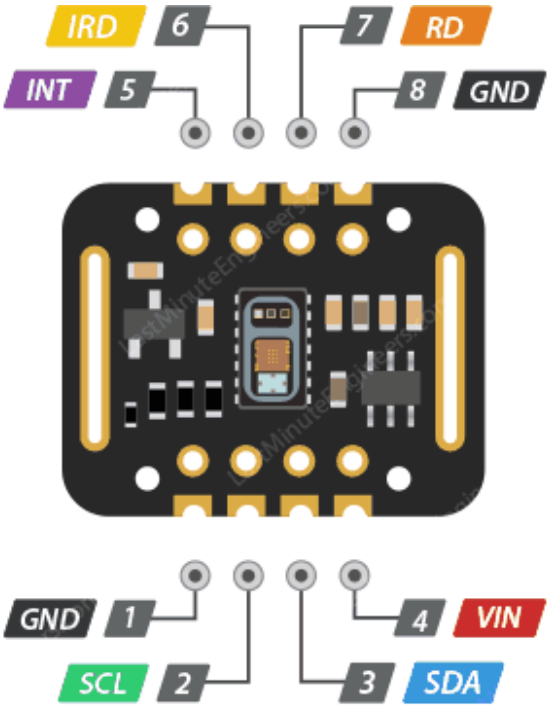
Pulse oximetry is based on the principle that different oxygen levels in the blood lead to different absorption levels of red and infrared light. The absorption spectra of oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (Hb) show that Hb absorbs more red light (660nm) and HbO2 absorbs more infrared light (880nm). By measuring the ratio of infrared to red light received by the photodetector, the oxygen level in the blood (SpO2) can be calculated.



Heart Rate Measurement:

Similarly, HbO2 absorbs more infrared light, and higher oxygen levels in the blood result in more infrared light absorption. Each heartbeat changes the intensity of reflected light as blood passes through the finger, which is captured by the photodetector to produce a waveform. By continuously shining light and reading data from the photodetector, the heart rate can be quickly determined. The changes in light intensity caused by each heartbeat correspond to the heart rate, and analyzing these periodic changes allows for calculating beats per minute (BPM).





MAX30102 Module Pinout

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Pin Configuration:

- VIN: Power input pin can be connected to a 3.3V or 5V output.
- SCL: I2C clock pin.
- SDA: I2C data pin.
- INT: Can be programmed to generate an interrupt for each pulse.
- IRD: Integrated LED driver for driving LED pulses and measuring SpO2 and HR.
- RD: Similar to the IRD pin but for driving the red LED, can be left unconnected.
- GND: Ground pin.